Claims

1. A method for assessing a measurement system under test (MSUT), the method comprising the steps of:

(a) providing a substrate having a plurality of structures;

(b) measuring a dimension of the plurality of structures using a reference measurement system (RMS) to generate a first data set, and calculating an RMS uncertainty (U_{RMS}) from the first data set, where the RMS uncertainty (U_{RMS}) is defined as one of an RMS precision and an independently determined RMS total measurement uncertainty (TMU_{RMS});

(c) measuring the dimension of the plurality of structures using the MSUT to generate a second data set, and calculating a precision of the MSUT from the second data set;

(d) conducting a linear regression analysis of the first and second data sets to determine a corrected precision of the MSUT and a net residual error; and

(e) determining a total measurement uncertainty (TMU) for the MSUT by removing the RMS uncertainty (U_{RMS}) from the net residual error.

2. The method of claim 1, wherein the plurality of structures represent variations in a semiconductor process.

3. The method of claim 1, wherein the dimension includes at least one of line width, depth, height, sidewall angle and top corner rounding.

4. The method of claim 1, wherein the TMU for the MSUT is determined according to the formula:

$$TMU = \sqrt{D^2 - U_{RMS}{}^2}$$

where D is the net residual error.

5. The method of claim 1, wherein the linear regression is calculated using a Mandel linear regression wherein a ratio variable λ is defined according to the formula:

$$\lambda = \frac{U_{RMS}{}^2}{U_{MSUT}{}^2}$$

where U_{MSUT} is as an MSUT uncertainty defined as one of the corrected precision of the MSUT and the TMU for the MSUT.

6. The method of claim 5, wherein, in the case that the TMU for the MSUT is substantially different than the MSUT uncertainty (U_{MSUT}) after step (e), steps (d) and (e) are repeated using the TMU for the MSUT as the MSUT uncertainty (U_{MSUT}) in determining the ratio variable λ.

7. The method of claim 5, wherein the TMU for the MSUT is determined according to the formula:

$$TMU = \sqrt{D_M{}^2 - U_{RMS}{}^2}$$

where D_M is the Mandel net residual error.

8. A method for optimizing a measurement system under test (MSUT), the method comprising the steps of:

(a) providing a plurality of structures;

(b) measuring a dimension of the plurality of structures according to a measurement parameter using a reference measurement system (RMS) to generate a first data set, and calculating an RMS uncertainty (U_{RMS}) from the first data set, where the RMS uncertainty (U_{RMS}) is defined as one of an RMS precision and an independently determined RMS total measurement uncertainty (TMU_{RMS});

(c) measuring the dimension of the plurality of structures according to the measurement parameter using the MSUT to generate a second data set, and calculating a precision of the MSUT from the second data set;

(d) conducting a linear regression analysis of the first and second data sets to determine a corrected precision of the MSUT and a net residual error;

(e) determining a total measurement uncertainty (TMU) for the MSUT by removing the RMS uncertainty (U_{RMS}) from the net residual error;

(f) repeating steps (c) to (e) for at least one other measurement parameter; and

(g) optimizing the MSUT by determining an optimal measurement parameter based on a minimal total measurement uncertainty.

9. The method of claim 8, further comprising the step of selecting a set of measurement parameters to be evaluated.

10. The method of claim 8, wherein the MSUT is an SEM and a measurement parameter includes at least one of: a data smoothing amount, an algorithm setting, a beam landing energy, a current, an edge detection algorithm and a scan rate.

11. The method of claim 8, wherein the MSUT is a scatterometer and a measurement parameter includes at least one of: a spectra averaging timeframe, a spectra wavelength range, an angle of incidence and area of measurement, a density of selected wavelengths and a number of adjustable characteristics in a theoretical model.

12. The method of claim 8, wherein the MSUT is an AFM and a measurement parameter includes at least one of: a number of scans, a timeframe between scans, a scanning speed, a data smoothing amount and area of measurement, and a tip shape.

13. The method of claim 8, wherein the plurality of structures represent variations in a semiconductor process.

14. The method of claim 8, wherein the dimension includes at least one of line width, depth, height, sidewall angle and top corner rounding.

15. The method of claim 8, wherein a total measurement uncertainty (TMU) for the MSUT is determined according to the formula:

$$TMU = \sqrt{D^2 - U_{RMS}^2}$$

where D is the net residual error.

16. The method of claim 8, wherein the linear regression is calculated using a Mandel linear regression wherein a ratio variable λ is defined according to the formula:

$$\lambda = \frac{U_{RMS}^2}{U_{MSUT}^2}$$

where U_{MSUT} is as an MSUT uncertainty defined as one of the corrected precision of the MSUT and the TMU for the MSUT.

17. The method of claim 16, wherein, in the case that the TMU for the MSUT is substantially different than the MSUT uncertainty (U_{MSUT}) after step (e), steps (d) and (e) are repeated using the TMU for the MSUT as the MSUT uncertainty (U_{MSUT}) in determining the ratio variable λ.

18. The method of claim 16, wherein the TMU for the MSUT is determined according to the formula:

$$TMU = \sqrt{D_M^2 - U_{RMS}^2}$$

where D_M is the Mandel net residual error.

19. A computer program product comprising a computer useable medium having computer readable program code embodied therein for assessing a measurement system under test (MSUT), the program product comprising:

(a) program code configured to measure a dimension of the plurality of structures using a reference measurement system (RMS) to generate a first data set, and calculate an RMS uncertainty (U_{RMS}) from the first data set, where the RMS uncertainty (U_{RMS}) is defined as one of an RMS precision and an independently determined RMS total measurement uncertainty (TMU_{RMS});

(b) program code configured to measure the dimension of the plurality of structures using the MSUT to generate a second data set, and calculate a precision of the MSUT from the second data set;

(c) program code configured to conduct a linear regression analysis of the first and second data sets to determine a corrected precision of the MSUT and a net residual error; and

(d) program code configured to determine a total measurement uncertainty (TMU) for the MSUT by removing the RMS uncertainty (U_{RMS}) from the net residual error.

20. The program product of claim 19, wherein the code configured to determine the TMU implements the formula:

$$TMU = \sqrt{D^2 - U_{RMS}^2}$$

where D is the net residual error.

21. The program product of claim 19, wherein the code configured to conduct the linear regression implements a Mandel linear regression wherein a ratio variable λ is defined according to the formula:

$$\lambda = \frac{U_{RMS}^{2}}{U_{MSUT}^{2}}$$

where U_{MSUT} is as an MSUT uncertainty defined as one of the corrected precision of the MSUT and the TMU for the MSUT.

22. The program product of claim 21, further comprising program code configured to, in the case that the TMU for the MSUT is substantially different than the MSUT uncertainty (U_{MSUT}), re-running the program code configured to conduct a linear regression analysis and the program code configured to determine TMU using the TMU for the MSUT as the MSUT uncertainty (U_{MSUT}) in determining the ratio variable λ.

23. The program product of claim 21, wherein the code configured to determine the TMU implements the formula:

$$TMU = \sqrt{D_M^{2} - U_{RMS}^{2}}$$

where D_M is the Mandel net residual error.

24. A computer program product comprising a computer useable medium having computer readable program code embodied therein for optimizing a measurement system under test (MSUT), the program product comprising:

(a) program code configured to measure a dimension of a plurality of structures according to a measurement parameter using a reference measurement system (RMS) to generate a first data set, and calculate an RMS uncertainty (U_{RMS}) from the first data set, where the RMS uncertainty (U_{RMS}) is defined as one of an RMS precision and an independently determined RMS total measurement uncertainty (TMU_{RMS});

(b) program code configured to measure the dimension of the plurality of structures according to the measurement parameter using the MSUT to generate a second data set, and calculate a precision of the MSUT from the second data set;

(c) program code configured to conduct a linear regression analysis of the first and second data sets to determine a corrected precision of the MSUT and a net residual error;

(d) program code configured to determine a total measurement uncertainty (TMU) for the MSUT by removing the RMS uncertainty (U_{RMS}) from the net residual error; and

(e) program code configured to optimize the MSUT by determining an optimal measurement parameter based on a minimal total measurement uncertainty selected from a plurality of total measurement uncertainties of a corresponding plurality of measurement parameters.

25. The program product of claim 24, wherein the code configured to determine the TMU implements the formula:

$$TMU = \sqrt{D^2 - U_{RMS}^2}$$

where D is the net residual error.

26. The program product of claim 24, wherein the code configured to conduct the linear regression implements a Mandel linear regression wherein a ratio variable λ is defined according to the formula:

$$\lambda = \frac{U_{RMS}^2}{U_{MSUT}^2}$$

where U_{MSUT} is as an MSUT uncertainty defined as one of the corrected precision of the MSUT and the TMU for the MSUT.

27. The program product of claim 26, further comprising program code configured to, in the case that the TMU for the MSUT is substantially different than the MSUT uncertainty (U_{MSUT}), re-running the program code configured to conduct a linear regression analysis and the program code configured to determine TMU using the TMU for the MSUT as the MSUT uncertainty (U_{MSUT}) in determining the ratio variable λ.

28. The program product of claim 26, wherein the code configured to determine the TMU implements the formula:

$$TMU = \sqrt{D_M^2 - U_{RMS}^2}$$

where D_M is the Mandel net residual error.